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Gastrointestinal Helminths of Night Lizards, Genus *Xantusia* (Xantusiidae)

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ABSTRACT: Examination of the gastrointestinal tracts of 278 *Xantusia vigilis*, 40 *Xantusia henshawi*, and 8 *Xantusia bolsonae* revealed the presence of 1 species of nematode, *Parapharyngodon californiensis* (prevalences 1, 28, and 50%, respectively). *Xantusia henshawi* and *X. vigilis* also harbored 1 species of cestode, *Oochoristica bezyi* (prevalences 35 and 16%, respectively). *Xantusia bolsonae* is a new host for *P. californiensis*. *Xantusia henshawi* and *X. vigilis* are new hosts for *O. bezyi*. Examination of the gastrointestinal tracts of 21 *Xantusia riversiana* revealed the presence of 6 species of nematodes: *Alaeuris clementensis, Alaeuris riversianae, Parapharyngodon pseudothaparius, Parapharyngodon xantusi, Thubunaea iguanae,* and an unidentified oxyurid (prevalences 71, 81, 100, 90, 14, and 5%, respectively). One species of cestode, *Oochoristica islandensis* (prevalence 52%), also was present. *Xantusia riversiana* is a new host for *T. iguanae*. Compared to the mainland species of *Xantusia,* the helminth fauna of the insular *X. riversiana* is both unique and diverse. The high prevalences of helminths in *X. riversiana* may be due to the increased opportunity for infection and reinfection presented by its unusually dense populations and overlapping home ranges.

KEY WORDS: Cestoda, *Oochoristica bezyi, Oochoristica islandensis,* Nematoda, *Alaeuris clementensis, Alaeuris riversianae, Parapharyngodon californiensis, Parapharyngodon pseudothaparius, Parapharyngodon xantusi, Thubunaea iguanae,* Xantusiidae, *Xantusia bolsonae, Xantusia henshawi, Xantusia riversiana, Xantusia vigilis,* prevalence, intensity.

The 20 living species of the New World lizard family Xantusiidae are arrayed into 3 genera. The northernmost, *Xantusia,* consisting of 4 habitat-specialized species, comprises the focus of the present study. The only widely distributed member of the genus is the desert night lizard, *Xantusia vigilis* Baird, 1858, which ranges discontinuously from central California and southern Utah, south to Baja California Sur and Zacatecas, Mexico, and inhabits yuccas, agaves, and other plants (Bezy, 1982). The cestode *Oochoristica scelopori* Voge and Fox, 1950, and the nematode *Parapharyngodon californiensis* (Read and Amrein, 1952) Adamson, 1981, have been reported from *X. vigilis* by Amrein (1951) and Telford (1970).

The granite night lizard, *Xantusia henshawi* Stejneger, 1893, lives exclusively beneath exfoliations of boulders in the peninsular ranges of southern California and northern Baja California (Lee, 1976). Read and Amrein (1952) and Telford (1970) reported *O. scelopori* and *P. californiensis* in *X. henshawi*. In addition, Telford (1970) recovered the nematode *Thubunaea iguanae* Telford, 1965.

A second rock-crevice specialist, the Bolsón night lizard, *Xantusia bolsonae* Webb, 1970, is known from only 2 localities in the southern Chihuahuan desert of Durango, Mexico (Flores-Villela et al., 1990). To our knowledge, there are no reports of helminths from this species.

The island night lizard, *Xantusia riversiana* Cope, 1883, is endemic to 3 of the California Channel Islands, where it occurs beneath rocks (Fellers and Drost, 1991). Amrein (1951) found *O. scelopori, Parapharyngodon bicaudatus* (Read and Amrein, 1952) Adamson and Nasher, 1984, and *Alaeuris waltoni* (Read and Amrein, 1952) in *X. riversiana*. Lucker (1951) reported *Parapharyngodon pseudothaparius* (Lucker, 1951) Adamson and Nasher, 1984, and *P. xantusi* (Lucker, 1951) Adamson and Nasher, 1984. Telford (1970) found the cestode *Mesocestoides* sp. in addition to *O. scelopori* and 4 nematodes: *Alaeuris clementensis* (Telford, 1965) Baker, 1987, *Alaeuris riversianae* (Telford, 1965) Baker, 1987, *Parapharyngodon pseudothaparius,* and *P. xantusi*. Goldberg (1985) described the histopathology of infection by *Mesocestoides* sp.

In this paper we report the results of examination of gastrointestinal tracts from a total of 347 individuals of the 4 species of *Xantusia,* in-

Table 1. Helminth prevalences in 4 species of *Xantusia*, night lizards.

	Mainland species			Insular species
	X. bolsonae	*X. henshawi*	*X. vigilis*	*X. riversiana*
Cestoda				
Oochoristica bezyi	—	35% (14/40)	16% (44/278)	—
Oochoristica islandensis	—	—	—	52% (11/21)
Nematoda				
Alaeuris clementensis	—	—	—	71% (15/21)
Alaeuris riversianae	—	—	—	81% (17/21)
Parapharyngodon californiensis	50% (4/8)	28% (11/40)	1% (2/278)	—
Parapharyngodon pseudothaparius	—	—	—	100% (21/21)
Parapharyngodon xantusi	—	—	—	90% (19/21)
Thubunaea iguanae	—	—	—	14% (3/21)
Unidentified oxyurid	—	—	—	5% (1/21)

cluding the previously unsurveyed *X. bolsonae*, summarize the taxonomy, occurrence, and prevalence of the helminth parasites, and discuss these from ecological and evolutionary perspectives.

Materials and Methods

Two-hundred seventy-eight *Xantusia vigilis* (40.2 mm snout–vent length [SVL] ± 6.8 SD) were collected in August 1972 by the third author (R.L.B.). Two-hundred eight were from 5.9 km (by Highway N6) south of Pearblossom, Los Angeles County, California (34°27′N, 117°54′W, elevation 1,219 m) (Los Angeles County Museum of Natural History [LACM] 138685–138687, 139140, 139143, 139145–139146, 139148–139149, 139152, 139154–139175, 139177–139352). Seventy were from Hesperia, San Bernadino County, California (34°26′N, 117°17′W, elevation 975 m) (LACM 139353–139385, 139387–139390, 139392–139395, 139397–139425). Forty *X. henshawi* (55.5 mm SVL ± 5.4 SD) were examined. They were collected in the late 1960's at Cabazon (33°55′N, 116°47′W, elevation 1,790 m) Riverside County, California (LACM 100713–100716, 100718–100719, 100727–100730, 100732, 100735–100737, 100739–100741, 100743, 100745–100758, 100760–100763, 100765, 100767–100769). Eight *X. bolsonae* (46.5 mm SVL ± 7.1 SD) were examined. They were collected in the early 1970's at 16 km NNW of Pedriceña (25°15′N, 103°42′W, elevation 1,340 m) Durango, Mexico (LACM 72324–72325, 76156–76157, 76159, 106805–106806, 116260). Twenty-one *X. riversiana* (69.6 mm SVL ± 15.1 SD) collected by the senior author (S.R.G.) in June 1970 on the northwest end of San Clemente Island (33°2′N, 118°36′W, elevation 30 m) were examined (LACM 139106–139126). All specimens had been preserved in 10% formalin. None of the preceding samples were from sympatric populations.

The esophagus, stomach, small intestine, and large intestine were examined separately under a dissecting microscope. Each cestode was identified utilizing a glycerol wet-mount procedure. Selected specimens were stained with Delafield's hematoxylin and mounted in Canada balsam for study as whole mounts. Nematodes were identified utilizing a glycerol wet-mount procedure.

Representative helminths were deposited in the U.S. National Parasite Collection, Beltsville, Maryland 20705: *Oochoristica bezyi* (81873–81874), *Oochoristica islandensis* (82224–82225), *Alaeuris clementensis* (82174), *A. riversianae* (82175), *Parapharyngodon californiensis* (82172–82173, 82179), *P. pseudothaparius* (82176), *P. xantusi* (82177), *Thubunaea iguanae* (82178), unidentified oxyurid (82211).

Results

Prevalence of infection for each species of night lizard is presented in Table 1. *Xantusia vigilis* harbored 1 species of cestode, *Oochoristica bezyi* Bursey and Goldberg, 1992, and 1 species of nematode, *Parapharyngodon californiensis*, A total of 134 *O. bezyi* were removed from the small intestines of 44 lizards (prevalence 16%). Seven *P. californiensis* were recovered from the large intestines of 2 lizards (prevalence 1%). By locality, 35 of the 208 lizards from Pearblossom (prevalence 17%) and 9 of the 70 lizards from Hesperia (prevalence 13%) were infected; prevalences were not significantly different ($\chi^2 = 0.45$, 1 df, $P > 0.05$). For sex, 13 of 84 males (prevalence 15%) and 31 of 194 females (prevalence 16%) were infected ($\chi^2 = 0.01$, 1 df, samples not significantly different, $P > 0.05$). The mean intensity of *O. bezyi* for the sample was 3.0 (range 1–11); by subsample, Pearblossom, 3.2 (range 1–11), Hesperia, 2.6 (range 1–6). When the intensities of infection by subsample were analyzed statistically, significant differences were found (ANOVA, $F = 5.86$, 1 and 42 df, $P < 0.05$). One female lizard from Pearblossom ($N = 208$) contained 1 *P. californiensis* (prevalence <1%) and 1 female lizard from Hesperia ($N = 70$) contained 6 *P. californiensis* (prevalence 1%).

Xantusia henshawi harbored 1 cestode, *Oochoristica bezyi,* in the small intestines and 1 nematode, *Parapharyngodon californiensis* in the large intestines. Prevalence of *O. bezyi* was 35% (14/40) and mean intensity was 2.0 (range 1–6). There was no significant difference for prevalence of infection ($\chi^2 = 0.43$, 1 df, $P > 0.05$) nor mean intensity of infection (Kruskal-Wallis statistic = 0.41, 1 df, $P > 0.05$) between male and female lizards. Prevalence of *P. californiensis* was 28% (11/40) and mean intensity was 1.9 (range 1–7). There was no significant difference for prevalence ($\chi^2 = 0.12$, 1 df, $P > 0.05$) for mean intensity (Kruskal-Wallis statistic = 0.07, 1 df, $P > 0.05$) between male and female lizards.

Xantusia bolsonae harbored only the nematode, *Parapharyngodon californiensis,* in the large intestines. Prevalence was 50% (4/8) and mean intensity was 2.5 (range 1–5). Due to the small sample size, no statistical analyses were attempted.

Xantusia riversiana harbored 1 species of cestode, *Oochoristica islandensis* Bursey and Goldberg, 1992, in the small intestines and 6 species of nematodes: *Alaeuris clementensis, A. riversianae, Parapharyngodon pseudothaparius, P. xantusi,* and an unidentified oxyurid nematode in the large intestines and *Thubunaea iguanae* in the stomachs. Prevalence, mean intensity, and range for each species of helminth are as follows: *Oochoristica islandensis,* 52%, 1.3, 1–44; *A. clementensis,* 71%, 199.7, 6–85; *A. riversianae,* 81%, 218.8, 2–1,027; *P. pseudothaparius,* 100%, 82.5, 5–198; *P. xantusi,* 90%, 38.5, 2–145; *Thubunaea iguanae,* 14%, 1.3, 1–2; and unidentified oxyurid, 5%, 3. The *X. riversiana* sample contained 11 males and 10 females and was tested statistically for differences in prevalence of infection by *Oochoristica islandensis, A. clementensis, A. riversianae,* and *P. xantusi* between male and female lizards. All 21 lizards were infected by *P. pseudothaparius. Thubunaea iguanae* was recovered from 1 male and 2 female lizards; the unidentified oxyurid was recovered from 1 female lizard. There was no significant difference (1 df, $P > 0.05$ each test) in prevalence between male and female lizards ($\chi^2 = 0.44$ for *O. islandensis,* 3.22 for *A. clementensis,* 0.01 for *A. riversianae,* and 0.0 for *P. xantusi*). Male and female lizard subsamples were also tested statistically for differences in mean intensity of infection by *O. islandensis, A. clementensis, A. riversianae, P. pseudothaparius,* and *P. xantusi.* There was no significant difference (1 df, $P > 0.05$ each test) in mean intensity between male and female lizards (Kruskal-Wallis statistic, 0.14 for *O. islandensis,* 1.38 for *A. clementensis,* 0.83 for *A. riversianae,* 0.83 for *P. pseudothaparius,* and 0.80 for *P. xantusi*). The 3 lizards infected by *T. iguanae* had intensities of 1, 1, and 2. The unidentified oxyurid (3 nematodes) was recovered from a single lizard.

Discussion

With the exception of *Thubunaea iguanae,* the helminths recovered in this study are apparently restricted to xantusiid lizards. *Thubunaea iguanae* has been recovered from New World gekkonid, phrynosomatid, crotaphytid, teiid, and xantusiid lizards. Telford (1970) speculated that the infection period for *T. iguanae* was concentrated in 2 parts of the year: December–January and May–June. The periods September–December and March–April were passed as eggs outside of the definitive hosts or as developing larvae in the arthropod intermediate hosts. Our collecting period for *X. riversiana* was June, thus within Telford's (1970) stated infective period. The unidentified oxyurid recovered from *X. riversiana,* we believe, is not a typical lizard parasite and most likely an incidental infection.

Both Amrein (1951) and Telford (1964) reported *Oochoristica scelopori* from *Xantusia henshawi, X. vigilis,* and *X. riversiana,* although the measurements of the cestodes were strikingly different. In Amrein's (1951) study, the average length of 25 mature worms from *X. vigilis* and *X. henshawi* was 16 mm, whereas those from *X. riversiana* were 33–37 mm. Telford (1964) reported that his cestode specimens from xantusiid lizards were less than 45 mm. Our measurements for these cestodes from the same host species are similar to those of the preceding authors and are much less than those given in the original description of *O. scelopori* by Voge and Fox (1950). The smaller *Oochoristica* found in *X. vigilis* and *X. henshawi* was described as *O. bezyi* by Bursey and Goldberg (1992b), whereas the larger one in *X. riversiana* was described by Bursey and Goldberg (1992c) as *O. islandensis.* Thus, we believe that all 3 species of *Xantusia* should be removed from the host list for *O. scelopori,* leaving only phrynosomatid and crotaphytid lizards as hosts for this cestode (see Bursey and Goldberg, 1992b).

All but 1 helminth species appear to be unique to lizards of the genus *Xantusia,* and none is shared with *Cricosaura typica,* the only other xantusiid that has been examined (Barus and Coy-

Otero, 1974; Baker, 1987). Two genera, *Parapharyngodon* and *Oochoristica,* are particularly interesting in terms of their occurrences within *Xantusia. Parapharyngodon pseudothaparius* and *P. xantusi* have been recovered only from the insular *X. riversiana,* whereas *P. californiensis* has been found exclusively in the 3 mainland species of *Xantusia* (*X. bolsonae, X. henshawi,* and *X. vigilis*). *Oochoristica islandensis* is known only from *X. riversiana,* whereas *O. bezyi* has been found exclusively in *X. henshawi* and *X. vigilis.* As a phylogeny is not currently available for these helminths, it is not possible at this point to evaluate whether the sharing of unique helminths among the mainland species of *Xantusia* results from co-speciation or from independent acquisition and co-accommodation (Brooks, 1979).

The helminth data are also interesting from a biogeographical and ecological viewpoint. The insular endemic *X. riversiana* is found to have a unique and relatively diverse oxyurid fauna that is not shared with any of the mainland species. Bezy et al. (1980) estimated that *Xantusia riversiana* may have been isolated on 1 or more of the Channel Islands for as much as 5 million years. The high level of helminth endemism in *X. riversiana* is an additional source of evidence for a long period of insular isolation. Insular endemism is also characteristic of these oxyurid genera. Of the 33 species of *Parapharyngodon* (see Baker, 1987), 10 (30%) are found only on islands. Similarly, 12 (36%) of the 33 species of *Alaeuris* are known exclusively from islands (see Baker, 1987).

Interestingly, such helminth endemism is not characteristic of *Uta stansburiana,* the only other species of lizard with which *Xantusia riversiana* co-exists on San Clemente Island. Telford (1970) examined 51 *U. stansburiana* from San Clemente Island and found only *Spauligodon giganticus.* This nematode occurs in 6 mainland lizard species (Bursey and Goldberg, 1992a) but is not currently known from mainland *U. stansburiana. Xantusia riversiana* and *U. stansburiana* do not have any helminth species in common, although these 2 lizards are sympatric on San Clemente Island and may even be found under the same rock. The founding of an island population of *U. stansburiana* may be relatively recent, whereas the helminths of *X. riversiana* may be of longer standing.

Brattstrom (1952) examined stomach contents of species of *Xantusia* and found that *X. riversiana* has the most varied diet, which includes insects, spiders, and substantial amounts of vegetation. Fellers and Drost (1991) reported *X. riversiana* to have a diverse diet and to consume an unusually large proportion of plant material. Our measurements of stomach contents at necropsy are also in agreement (14.5% plant and 85.5% animal matter by dry weight). *Xantusia henshawi* was found to eat primarily spiders and other arthropods, whereas *X. vigilis* is mainly insectivorous (Brattstrom, 1952). We found that *Xantusia bolsonae* is also insectivorous. That there is an association between the herbivory of *X. riversiana* and a more diverse helminth fauna is strongly suggested by the high percentage of primarily herbivorous reptiles that are hosts for species of *Alaeuris* (87%, 20/23) (see Baker, 1987).

We also believe that certain aspects of the ecology of *X. riversiana* are responsible for their greater helminth prevalences than found in mainland xantusiids, which, in comparison, have a depauperate helminth fauna. *Xantusia riversiana* have very small home ranges, about 17.2 m^2, they are slow growing, and some individuals live to be at least 12 yr old (Fellers and Drost, 1991). Due to their diet, low metabolism, and small overlapping home ranges, they reach densities (1,700–3,200/ha) greater than any other ground-dwelling lizard (Fellers and Drost, 1991). In contrast, *X. vigilis* has a much lower density of 49/ha (Zweifel and Lowe, 1966). Also, all 3 mainland species occupy spatially disjunct habitats (boulders and yuccas) in which home ranges are not continuously overlapping.

All of the nematodes so far recovered from night lizards are oxyurids with the exception of the spirurid *Thubunaea iguanae.* Oxyurid nematodes have, as far is known, direct life cycles and infection is probably due to fecal contamination (Telford, 1971). Spirurids presumably require an insect intermediate host and *Thubunaea iguanae,* in particular, is thought to have a short life cycle (Telford, 1964). The population density reached by *X. riversiana* as well as overlapping home ranges may allow fecal buildup, which could provide numerous opportunities for infection and reinfection of oxyurids. Also, the larger body size of *X. riversiana* may provide greater opportunity for helminth infection without undue damage to the host.

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Errata

Publication cost of the paper titled, A coprological survey of parasites of wild muriquis, *Brachyteles arachnoides,* and brown howling monkeys, *Alouatta fusca,* by M. D. Stuart et al., which appeared in the January issue of this journal, Volume 60(1):111–115, was supported by the Brayton H. Ransom Memorial Trust Fund. The Editor regrets the oversight.